

THINGS

of science



SOUND

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SOUND

Stop—and listen to the sounds around you. What a variety of sounds you can hear! The rumbling noise of a passing truck, the chirping of a bird, the rattling of papers, voices in the distance or nearby, footsteps on the walk, the jingling of a bicycle bell. How divergent these sounds and how readily we can distinguish one from the other.

Sounds are one of the most important sources of information about our surroundings and are of primary importance in our communications with one another. When we hear raindrops splashing against the window panes, we do not need to see them to know it is raining, nor when we hear the cry of a child, is it necessary for us to see the tears to know he is in distress.

During infancy we learned that we could attract attention by creating sounds and as we grew older we learned that particular sounds (words) achieved particular results. We also found that certain noises meant certain things, like the banging of a door or the clatter of dishes in the kitchen. Most sounds could be related to definite causes, a knowledge gained from our experiences. Thus the sound of a doorbell would not be confused with the noise of a typewriter, or the sound of a rooster's crow with the mooing of a

cow. What gives each sound its characteristics and how are they transmitted to us?

What is sound? What are its properties?

The study of sound involves several fields of science—physics, physiology and psychology. In this unit we will concern ourselves primarily with the physics of sound, assuming there are ears to hear and respond to it.

With the materials in this unit you will learn something about the nature of sound and how it is produced.

First look over your materials.

JINGLE BELL

GONG

DOUBLE REED WHISTLE

PLASTIC TUBE

RUBBER BAND

METAL STRIP

WHAT IS SOUND?

All sounds originate from something that moves.

Experiment 1. Take your metal strip and apply a piece of cellophane tape to each end to protect your fingers from the cut edge.

Place one end of the metal strip on the edge of a table allowing about three inches to extend beyond the edge. Hold the end down securely on the table and push down on the free end then release

it suddenly. You will hear a low humming sound as the metal vibrates.

Now take the metal strip and move it back and forth in the air. No sound is produced.

Clap your hands together. You will hear a sharp sound. Push them slowly together. No sound is heard.

Although any sound results from something that moves, all movements do not produce sounds. Sound results from a certain kind of motion that causes molecules, usually air molecules, to behave in a particular way. The molecules move to and fro in a regular pattern, and as the molecules collide together the pattern moves outward from the source of the sound.

The air is composed of molecules that are constantly moving around in every direction, bumping into each other in a random sort of way—without direction, but scattered about more or less uniformly.

When the metal strip in your experiment moves upward, it pushes the molecules above it against each other crowding them together into a smaller space. This is called compression. When it moves downward it leaves behind it more space for the air molecules, resulting in rarefaction (Fig. 1). As the metal vibrates the molecules are alternately compressed and rarefied in quick succession. The

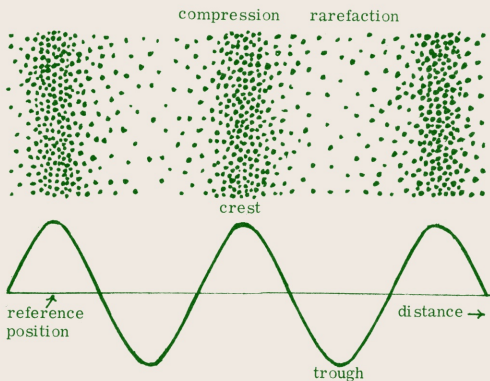


Fig. 1

compressions and rarefactions form a type of wave motion known as longitudinal waves. These waves move outward from the source, and on reaching our ears, cause the eardrum to vibrate and are interpreted as sound.

When you simply move the steel strip back and forth, the air molecules are disturbed but the movement is not quick enough to produce sound waves to which the ear is sensitive, and no sound is heard.

Clapping your hands together disturbs the air causing compressions and rarefactions of the molecules in the surrounding air, but moving your hands slowly together, while it may disturb the air, produces no discernible wave motion of

compression and rarefaction.

Experiment 2. Listen for a sound and then locate its source. You will find that in most cases you will be able to discover the movement causing the sound.

In order for sound waves to reach our ears, they must have a means of traveling. In most instances it is the air that serves as the medium. Some 300 years ago the famous scientist Robert Boyle showed that sound waves cannot travel through a completely empty space such as a vacuum. But any substance that is elastic, that is, whose molecules can move freely back and forth—gas, liquid or solid—will transmit sound.

We cannot see sound waves, but we can acquire some idea of how they travel by observing the behavior of water waves.

Experiment 3. Fill a large basin with water and tap the surface of the water with one end of your metal strip. Waves will spread outward in ever widening circles. Sound waves travel in much the same way from the source of a sound. A hammer striking a nail will disturb the air just as the metal strip disturbs the water, causing compression and rarefaction of the air molecules.

However, while water waves travel just across the surface, sound waves travel in all directions around the sound-producing object, completely encircling it in a sphere of waves. Because longitudinal

waves travel in every direction, the same sound can be heard from all sides.

Experiment 4. Now tap the water in a steady rhythm with the steel strip. Waves of the same size are created continuously. Just as these waves move at a steady rate across the water, so will sound waves produced by a vibrating object move steadily outward through the air.

The molecules of air themselves do not travel along with the waves. They just pass the compression and rarefaction along to neighboring molecules. Water waves behave similarly.

Experiment 5. Place a small floating object such as a cork on the surface of the water and then produce waves as before. The object will bob up and down on the waves but will remain in approximately the same location.

The air molecules compressed together by the vibrating steel begin to expand immediately and when they do so, they collide with neighboring molecules. These molecules in turn collide with their neighbors. The compressions are passed on in this way moving along at high speed with the rarefactions following behind.

In the water waves the molecules travel up and down, while in sound waves they are squeezed together and then released in a back and forth sideways direction.



Fig. 2

The compression of a sound wave is like the crest of the water wave and the rarefaction like the trough (Fig. 1).

Sound waves are usually represented by a curved line with the top of the curve the compression and the bottom as the rarefaction (Fig. 2). The line, however, is not an actual picture of a wave, but a diagram.

Sound waves may be produced in a number of ways, such as by means of vibrating objects, a steady air stream passing through a tube, explosions or by the impact of two objects colliding.

VIBRATING OBJECTS

What are some of the properties of vibrating objects?

Experiment 6. A pendulum is a simple vibrating system. Attach a string about 10 inches long to the loop on the jingle bell and allow it to swing freely from a nail or other projection. It will swing back and forth or oscillate in a regular

motion until it finally stops.

Observe one complete to and fro swing. This is known as a cycle. The number of cycles it performs in one second is defined as its frequency (cycles per second, cps).

As the pendulum swings, gradually shorten the string and you will notice that the pendulum swings through a cycle faster. Its frequency is increased.

The pendulum is a vibrating object as it swings back and forth, but we cannot hear it. In order to produce a sound audible to the human ear, a body must vibrate a certain number of times per second or have a minimum frequency. This minimum frequency is about 20 cps. The maximum frequency we can hear is about 20,000 cps. Sound waves having a frequency below 20 cps or above 20,000 cps are inaudible to us and are called infrasonic and ultrasonic sounds respectively.

Experiment 7. Hold one end of your metal strip down firmly on a table allowing it to extend about $4\frac{1}{2}$ inches beyond the edge. Push the free end down about one-half inch and then release it. Do you hear a sound as it vibrates? If not, the vibration is too slow to be audible.

Experiment 8. Now hold one end of the metal strip down on the table again, but this time allow only $2\frac{1}{2}$ inches to extend from the edge of the table. Vibrate

the metal strip again by pressing down on its free end. Do you hear a sound this time? By shortening the strip you have increased the frequency of the vibrations sufficiently so that an audible sound is produced. Can you see that the strip when shortened vibrates faster?

Experiment 9. Stretch your rubber band across the length of the top of your THINGS box. With the inside of the box facing up, pluck the rubber band while holding the box in your hand. Do you feel the vibrations as well as hear the sound they produce? You can observe from this experiment that a vibrating object produces sound.

Experiment 10. Hold one end of your metal strip lightly between your fingers and pull it across a hard rough surface. Note the sound it produces and the sensation in your fingers at the same time. The metal strip is vibrating although the vibrations are so small they are invisible.

Experiment 11. Obtain a clean very thin glass. Wet the middle finger of one hand and rub it back and forth along the rim while holding the glass securely with your other hand. You will hear a distinct singing sound. Can you see the glass vibrate?

Let us demonstrate that vibrations do occur although you cannot see them. Place your metal strip across the top of the glass and repeat the experiment. What

happens to the strip? The vibrations in the glass are transmitted to the metal.

You have shown that vibrations produce sounds. But in order for sound to be sustained, an object must continue to vibrate.

Experiment 12. Pluck the rubber band again and note that the sound disappears if you touch it and stop the vibrations.

Suspend your gong with a string and strike it with the metal strip. You will hear a clear ringing sound that gradually fades away.

Now strike it again but immediately place it on a table. What happens to the sound? Why?

Experiment 13. Hold the string of the jingle bell you used as a pendulum and shake it. Note that the bell rings, but the sound is produced only on impact by the sounder inside and is not sustained by the metal giving it the characteristic jingling sound of this type of bell. The metal does not continue to vibrate.

Musical instruments that produce sounds when struck are known as percussion instruments. The gong and bell are examples of this type of instrument.

Experiment 14. Blow up a paper bag and then pop it by striking it. The paper bag is destroyed and does not vibrate, but creates a sound wave by compressing

the air around it when its air is released forcefully. Explosions produce sounds in the same way.

FREQUENCY

You have observed that the frequency of a pendulum is increased when it is shortened and decreased when it is lengthened. In general, as the size of a vibrating object is decreased, its frequency is increased. Compare a piccolo to a flute, or a violin to a bass violin, or a snare drum to a bass drum.

Experiment 15. Place your metal strip about a half inch within the edge of the table and vibrate it. Decrease the length of the strip extending beyond the table gradually and as you vibrate it with each change in length, note that the strip vibrates faster as the length becomes

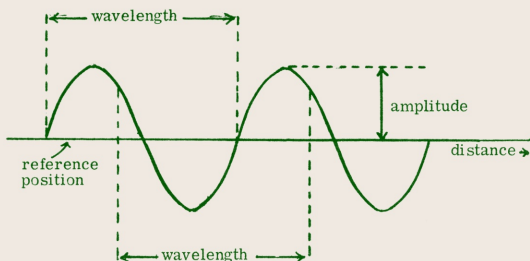


Fig. 3

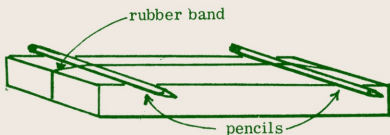


Fig. 4

shorter.

A single cycle of the steel strip is one up-and-down motion. A wavelength corresponds to the distance moved by the wave in the time required for a single cycle to occur (Fig. 3).

The greater the number of cycles per second, the higher the frequency. As the frequency increases, the wavelength becomes shorter.

The wavelength is also the distance between any point of the wave to the next point on a wave having exactly the same character (Fig. 3).

Experiment 16. Repeat Experiment 15 paying attention this time to the sound. Does the sound become higher or lower in pitch as the vibrations are increased?

Experiment 17. Stretch the rubber band in your unit across the top of your THINGS box with the outside up this time. Place a pencil under the rubber band at each end (Fig. 4).

Pluck the rubber band and note the tone. Now move one of the pencils about

1½ inches closer to the other keeping the tension of the rubber band the same. To prevent the rubber band from stretching more in one direction than the other remove the pencil and then reinsert it at the desired position. Pluck the rubber band and note the tone. Is it higher in pitch?

Move the pencil another inch closer. Is the pitch still higher?

Shortening the rubber band as in shortening the metal strip increases the frequency of vibrations. When the frequency is increased, the tone becomes higher pitched. The lower the frequency, the longer the wavelength and the lower the pitch, and the higher the frequency, the shorter the wavelength and the higher the pitch.

Frequency is a physical property and can be measured, while pitch is a subjective sensation, psychological and physiological, depending mostly on the rate of vibration and our perception of the sound waves created. A human sensation such as this cannot be measured directly.

Usually wavelengths in air ranging from about ¾ inch to about 55 feet in length are audible to the human ear.

Experiment 18. Stretch the rubber band across the box again with the inside facing up and vibrate it noting the sound. Now secure the rubber band at one end with your thumb and then pull it from

the other end around the box so that it is stretched more tightly across the space. Now pluck it. Is the pitch higher? Repeat, stretching it tighter. Is the pitch still higher? As the tension is increased the pitch is raised.

In string instruments, the pitch of a note depends upon the length of the string as well as the tension.

Experiment 19. Place the rubber band across the box top again and vibrate it with the hollow side facing up, noting the sound. Now press it down $1\frac{1}{2}$ inches from one edge and vibrate it. Is the pitch higher or lower? You have increased the tension and shortened the rubber band at the same time and the sound is higher pitched.

A violinist presses down on the strings in order to produce similar conditions, changing the tension and length of the strings to produce various tones.

If you look at the strings of a violin you will find that some are thicker than others. The thickness of a string is also important in producing different tones.

Experiment 20. Using rubber bands of different widths, devise an experiment to demonstrate this.

From the above observations can you surmise why a harp is shaped like it is rather than rectangular? Which strings on a harp are the high pitched ones?

Experiment 21. The next time you see

a speeding ambulance with siren blowing listen carefully and note if there is a change in pitch as it rushes past you.

Usually the source of a sound is stationary. However, if the sound source is a screaming siren in a speeding ambulance moving rapidly toward you, you will notice that the pitch of the siren suddenly drops as the vehicle passes by you. As it rushes toward you the sound waves become crowded together and shortened, making the sound seem higher pitched although the siren itself retains the same frequency throughout. When the ambulance is right opposite you and as it speeds on its way, the pitch becomes suddenly lower because the distance between the condensations and rarefactions now become greater or an increase in wavelength occurs.

This phenomenon is known as the Doppler effect.

The Doppler effect is also observed if a sound source is stationary and you are moving rapidly toward or away from it.

The Doppler effect has nothing to do with loudness which is not the same as pitch.

HOW FAST IS SOUND?

It takes time for anything to travel in matter, including sound waves and other types of waves.

Experiment 22. Observe the speed of

water waves produced in the basin of water. In comparison to sound waves, they travel very slowly. Time the leading edge of the first wave and calculate the speed in seconds.

$$\text{Speed} = \frac{\text{distance}}{\text{time in seconds}}$$

Light waves travel the fastest of all waves, traveling at more than 186,000 miles per second.

Sound waves travel at a speed of about 1,100 feet per second ($\frac{1}{5}$ of a mile per second) in air—much more slowly than light. That is why you can see the flash of lightning before you hear the first clap of thunder in a thunderstorm. You can calculate the distance of a thunderstorm by noting the time lag.

Sound travels more quickly at high temperatures than at low and more quickly in some materials than in others.

Steel which is much more elastic than air transmits sound at about 17,000 feet per second, while in water, sound travels at about 5,000 feet per second, and through the earth it travels about six miles a second.

Knowing the speed of sound in water oceanographers can map the ocean floor by means of an instrument known as the fathometer. A sound is sent down into

the water and reflected. From the time taken for an echo to return, the depth can be calculated.

But all sounds, whether loud or soft, of high or low frequency, travel at about the same rate through the same medium. If this were not so, music would be a confused mixture of sounds.

REFLECTION OF SOUND

Experiment 23. Fill a basin with water and tap the surface of the water about 6 inches from one edge. What happens to the water waves? Note that they are reflected by the side of the basin and return, passing through any oncoming waves.

Sound waves are also reflected in a similar manner when they strike objects in their path. We do not ordinarily notice this since in the usual room sounds are reflected so quickly they blend with the original sounds.

But if you should enter a large empty hall and shout, your voice would be reflected and you would hear an echo if you are standing at the right distance from the wall.

The ear can hear sounds separately only if they are spaced at least $1/10$ of a second apart. Since sound travels 1,100 feet per second, the walls must be a minimum of 55 feet away in order for you to hear an echo. Depending upon the

position of the walls, an echo may bounce back and forth between them before fading away.

Experiment 24. Most of you probably have experienced the pleasure of hearing your voice echoing from a mountainside. You may have noticed that when you shouted several times in quick succession, the echoes were clear and distinct.

Tap the surface of the water in the basin with the tip of the handle of a spoon and your metal strip at the same time, holding them about six inches apart. Watch the waves. They will meet and pass through each other and proceed on their ways without interruption. Sound waves behave in a similar way. When sound waves meet, they do not interfere with each other but move along passing through each other maintaining their identity. That is why the echoes of repeated shouts are clear and undisturbed by approaching sound waves and also why we can hear distinct sounds, such as music and conversation at the same time.

Architects when constructing large auditoriums and halls take the reflection of sounds into consideration designing them so that a speaker will not hear echoes of his own voice and the music of an orchestra will not result in a confusion of sounds. This field of study is known as architectural acoustics. To

avoid echoes, usually a sound absorbing material is used on the walls and the walls are shaped to control the direction of reflected sound waves.

Sound waves like light waves can be focused at a particular spot. The famous whispering gallery in the Capitol in Washington, D.C. makes use of this property of sound waves. A whisper spoken in a certain location in the gallery and properly directed will produce a sound which can be heard only at another point in the room, where the sound waves are focused by the curved ceiling of the gallery.

Experiment 25. Talk into a jar or a bucket. Note how different your voice sounds. Does it seem louder or softer than in normal speech? The sounds are reflected from the walls of the hollow container and are efficiently directed back to your ears. Reverberations are produced when sound waves are reflected back and forth repeatedly between two surfaces until they die away.

Now line the bucket with a towel and talk into it. What happens to the sound of your voice? Explain your result.

DIFFRACTION

Experiment 26. Place a small object about two inches wide in the center of your basin of water being sure it protrudes above the surface. Then make a wave by striking the surface of the water

with your metal strip. What happens to the wave when it strikes the obstacle?

The wave bends around the object spreading across the space behind it and proceeds on its way. This bending of waves around objects is called diffraction.

Sound waves like water waves are also diffracted, and it is because of this that we can hear most of the sounds around us, no matter from which direction they may come.

Experiment 27. Open a window and place yourself away from it across the room. Note the various outdoor sounds you can hear. The sound waves bend around the sides of the open window and fill the room.

Longer wavelength sounds are diffracted more than short wavelength sounds.

Plug up one of your ears with cotton and then stand several feet away from a ticking clock with the plugged ear toward it. You will hear the clock only faintly or not at all. Now slowly turn your head toward the clock. You will hear the ticking as soon as the short high frequency sound waves produced by each tick can directly reach your unplugged ear.

Experiment 28. Go outdoors or stand by an open window where many sounds prevail and place one end of the plastic tube against your ear. Do you hear a

soft rushing sound? Some of the sound waves in the surrounding air enter the opening of the tube and reach your ear.

Ordinarily sound vibrations scatter in every direction in the air and your ear catches only some of them. Once the sound waves enter the tube, however, they cannot escape and your ear receives a concentration of vibrations.

This is the basis of the old-fashioned funnel-shaped hearing aid held to the ear. The sounds are caught by this instrument and channelled directly to the eardrum.

INTENSITY

When we listen to sounds we notice that some are louder than others. Loudness, like pitch, is a subjective sensation and is difficult to measure.

The sensation of loudness varies with the frequency, but mostly with the property known as the intensity of a sound. The intensity of a sound is due to the energy flow from a sound source and is represented by the amplitude of a sound wave (Fig. 3). This is really a measure of the extent of compression in each wave of the sound. The greater the intensity the greater the amplitude and the greater the pressure exerted on the eardrums as each wave of compression arrives. The sensation of loudness increases when the pressure increases. Thus loudness also depends upon the sensi-

tivity of a person's ears.

Intensity is expressed in units called decibels computed on a mathematical scale known as the logarithm scale. The intensity of a sound is the number of decibels above some predetermined reference. A whisper is calculated to be about 10 to 15 decibels; ordinary conversation 50 to 70 decibels. When sounds reach an intensity of much more than 100 decibels, they become painful to the ears because of the great pressure on the eardrums.

The loudness of a sound decreases as it travels away from its origin, since the energy in a given wave is spread over a larger and larger area as the wave moves away from its source.

Experiment 29. Suspend your gong with a string and strike it with the metal strip while holding it close to your ear and then with the same force strike it while holding it at arm's length. Notice how the loudness is decreased with distance.

As the sound waves travel away from a sound source, they spread in wider and wider spheres becoming more and more dispersed. As a result of this spreading, the sounds become dissipated exerting less and less pressure on the eardrums and gradually becoming fainter.

Experiment 30. Now strike the gong with greater force. You get a louder

tone of the same pitch. By striking it harder the gong vibrates with greater amplitude and causes a greater compression of the air molecules and increased intensity. The regions of compression in sound waves are those of high pressure and regions of rarefaction, low pressure.

Increasing the amplitude does not affect the frequency. How would you demonstrate this?

TRANSMISSION OF SOUND

Experiment 31. Hold a wrist watch below your ear just in front of your shoulder where it is barely audible. Now hold an end of the metal strip against the back of the watch with the tip of your finger and place the other end of the metal against your ear. Listen carefully. Do you hear the ticking of the watch much more clearly?

The transmission of sound depends upon the elasticity of a medium. Because steel is an elastic substance, the sound waves from the ticking watch are transmitted by it to the ear. The sound is louder because it is channelled along the strip and not dissipated in the air.

Experiment 32. Tie a string to your jingle bell and fasten the other end to the handle of an iron frying pan placed upside down on the table. Place one ear against the bottom of the pan covering the other with your hand or plugging it

with cotton. Hold the string and strike the bell. Do you hear the sound of the bell? Release the string and sound the bell again. Do you hear the bell this time? The sound waves from the bell were transmitted through the string to the frying pan.

Experiment 33. Try this experiment with a friend. Obtain a piece of thin string about 20 feet long and two empty tin cans with the lids removed. Check to see that there are no sharp edges in the cans that may cut you.

With a hammer and nail punch a small hole in the center of the bottom of each can. Insert the ends of the string into the holes from the outside and then make a large knot on each end to hold the string in the holes when pulled, or tie a short piece of toothpick on each end to prevent the string from slipping through. Now have your friend take one can and pull the string taut. Be sure that the string does not come in contact with any object along its length.

Ask him to talk into the can while you listen through the other. Can you hear his voice distinctly?

Experiment 34. Stretch the rubber band lengthwise across the box top. With the hollow side up, pluck the rubber band noting the sound. Now place one corner of the box against your ear and pluck the rubber band again. Is the sound

louder? The box takes up the vibrations of the rubber band and not only transmits them to your ear but amplifies the sound.

This is the principle of the soundbox of string instruments such as the violin. The vibrations of the strings are transmitted to the wooden frame of the violin through the bridge causing it to vibrate and amplify the sound. The air within the box resonates to the vibrations also, enriching and reinforcing the tones.

Every object that can vibrate has natural resonant frequencies and will vibrate when a tone of these frequencies is sounded.

Experiment 35. Find a small object and make a pendulum of the same length as the one with your jingle bell. Hang the two pendulums from a horizontal support such as a coat hanger. Allow one of the pendulums to swing. Soon the second pendulum will also begin to swing. Both pendulums will vibrate or swing back and forth with the same frequency. This is what happens when resonance occurs. When any vibrating object makes another vibrate with the same frequency the two are said to be in resonance.

If you should sing a loud note into a piano with the loud pedal depressed, you would hear a number of strings vibrate in response. Since the human voice is complex and a mixture of various fre-

quencies, it can cause resonance in more than one string. Each resonating string vibrates at a different frequency.

AIR COLUMNS

Experiment 36. Blow across one end of your plastic tube. It produces a sound of definite pitch. Your tube is a simple form of wind instrument.

A wind instrument may be open at both ends like a flute or closed off at one end as in some organ pipes.

While closing off one end with your finger, blow into the other end of the tube at an angle, aiming the stream of air so that it strikes just inside the tube. With a little experimenting you can produce a definite tone. Blowing the air into the tube causes a compression and rarefaction of the molecules of air within the column of a particular frequency and tone. The walls of the tube enclose the air and prevent the sound waves from spreading.

The sound waves when they strike the closed end are reflected and as you keep blowing they move back and forth within the tube passing through each other.

Experiment 37. Fill a glass with water. Place the tip of one end of the plastic tube just beneath the surface of the water. Blow across the other end of the tube and as you do so lower the tube gradually into the water. What happens to the pitch?

Now gradually raise the tube up to the top of the water as you blow. Note the change in pitch.

As the air column in the pipe grows shorter, the sound waves travel back and forth more quickly increasing the frequency of vibration and thus raising the pitch.

This is the principle on which the trombone is based. As the player blows into the instrument he uses a slide to lengthen and shorten the air column to produce tones of different frequencies.

Experiment 38. Examine your double reed whistle. **DO NOT** place it in your mouth now. You may swallow it. The two reeds of this mouthpiece vibrate when air is blown across them producing compressions and rarefactions in the air.

Insert the whistle into the tube (Fig. 5) and tape it to it. Now blow on it noting the pitch.

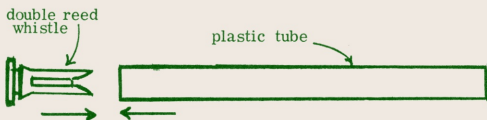


Fig. 5

With a nail or other sharp object, make a smooth round hole about $\frac{3}{16}$ inch in diameter about half way down the tube. Then blow it again. Is the pitch higher or lower? Place your finger on

and off the hole as you blow, and listen.

When you uncover the opening in the plastic tube, the result is the same as if you cut the tube off at this point since the opening allows the air to move freely in and out at that point.

In such instruments as the flute and clarinet different tones are produced by opening and closing holes placed at definite intervals along their lengths. The shorter the tube, the higher the frequency.

QUALITY

Objects producing sound vibrate in a complex manner. They may vibrate as a whole, in halves or thirds, or other combinations producing sounds known as overtones. It is the blending of these overtones with the fundamental or whole tone that determines the quality of the tone of an instrument and makes it possible for us to distinguish the sound of a violin from that of a trumpet.

Experiment 39. Have someone play the various sound makers in your unit where you cannot see them so that you can identify them by sound only. You will be able to differentiate the sound sources without any difficulty and would be able to do so even if the pitch of all the instruments were the same.

VOCAL CORDS

The human voice box, the larynx, is

the most versatile of all sound instruments. Located at the top of the windpipe, it consists of a tube, across which are stretched the vocal cords, soft elastic tissue. We produce sounds by forcing air across the vocal cords causing them to vibrate. By tightening or relaxing the cords we produce the pitch desired.

The sound waves pass into the mouth cavity which acts as a resonator and provides the overtones which give each voice its characteristic quality. Voices are very individual and voiceprints made as a person pronounces certain words show specific patterns. These patterns represent the quality of a person's voice which our ear also senses, and we use to identify a particular person's voice.

By shaping the lips and mouth we produce words. When we wish to speak loudly, we increase the amplitude of the sound waves by forcing greater puffs of air through the larynx to produce greater vibrations.

Through controlling the amount and force of the air passing across the vocal cords, adjusting the tension of the cords and varying the shape of the mouth cavity and lips, man can produce more varieties of sounds than any manmade instrument.

Experiment 40. Place your fingertips on your Adam's apple, which is the top of the voice box, while speaking. Can you

feel the vibrations?

The study of sound is a broad and complex field and you will probably wish to read further on the subject. The references below will be helpful.

Elementary physics books.

Experiments in Sound, Nelson F. Beeler, Thomas Y. Crowell Co., New York (1961).

Modern Sound Reproduction, Harry F. Olson, Van Nostrand-Reinhold Co., New York (1972).

Sound: From Communications to Noise Pollution, Graham Chedd, Doubleday Science Series, Doubleday & Co., Inc., New York (1970).

Sound and Hearing, Charles Gramet, Abelard-Schuman, New York (1965).

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